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# LIGNOCELLULOSIC DERIVED ACTIVATED CARBON MONOLITHS FOR EMERGING POLLUTANTS REMOVAL

Tomás Cordero, Francisco José García-Mateos, Paul O. Ibeh, Olaya Martínez, Juana Mª Rosas, José Rodríguez-Mirasol

[1] *Universidad de Málaga, Departamento de Ingeniería Química, Andalucía Tech, Facultad de Ciencias, Campus de Teatinos s/n, 29010 Málaga - Spain*

*Presenting author's e-mail: cordero@uma.es

## Introduction

Activated carbons are materials of great interest due to their versatility. Most of the activated carbons are prepared mainly in the form of powder, however, in certain processes, the powder-like morphology implies, high pressure drops and diffusional problems. A possible way to overcome these drawbacks is to prepare carbon materials directly into monolithic shape. The use of activated carbons as adsorbents in liquid phase adsorption has been widely studied. In the last few years, the elimination of emerging pollutants, as pharmaceutical compounds, personal care products, etc.., has taking special interest, due to their increase in concentration in water and their low elimination in traditional waste water treatments plants.

In this work, the use of activated carbon monoliths (ACMs) from different lignocellulosic precursors as adsorbents in aqueous phase of some emerging pollutants is presented.

## Materials and Methods

ACMs from olive stone were prepared by chemical activation with $H_3PO_4$ using a home-made extruder. Furthermore, an ACM derived from a natural monolith shape precursor, as Hemp cane, was also tested as ACMs adsorbent. Both precursors were impregnated with $H_3PO_4$ at an impregnation ratio of 2 ($H_3PO_4$/raw material mass ratio), and kept in a vacuum dryer for 24 hours, at 60 ºC. In case of the olive stone precursor, the impregnated sample, without any kind of binder, was conformed by extrusion in a home-made extruder, using a cylindrical mould with an internal diameter of 2 cm, at room temperature and 80 MPa, obtaining monoliths with 25 channels/cm$^2$. Subsequently, the obtained monoliths were activated in a tubular furnace at 700 ºC for 2 h, with a heating rate of 10 ºC/min. Finally, carbon monoliths were washed with distilled water at 60 ºC.

ACMs were characterized by adsorption-desorption of $N_2$ at -196 ºC, adsorption of $CO_2$ at 0 ºC, scanning electron microscopy (SEM), temperature programmed desorption (TPD), $NH_3$-TPD, and X-ray photoelectron spectroscopy (XPS). The adsorption of carbamazepine (CBZ) and paracetamol (PA) over these ACMs was analyzed at low concentrations (<10 mg/L) and at different temperatures (15, 25 and 35 ºC). Batch adsorption experiments were carried out in order to obtain the adsorption isotherms and the kinetic adsorption profiles of each pollutant. The simultaneous adsorption of both contaminants was also evaluated. These analyses were complemented with column experiments to obtain the corresponding breakthrough profiles.

## Results and Discussion

ACMs were obtained with preparations yields ranging from 36 to 40 % (weight ACMs/weight

raw material). These AMCs show well developed porosity, with apparent surface areas higher than 1250 $m^2/g$ and atomic phosphorus surface concentrations determined by XPS analyses between 0.8 and 1.94%. Figure 1 show SEM micrographs of the ACMs. Natural monoliths present an external diameter of around 7 mm. As can be seen, after the activation process, monolith keeps the channel structure characteristic of the hemp cane. Extruded ACM from olive stones presents a cross section of approximately 6 mm of diameter, with channel sizes ranging from 700 to 800 μm.

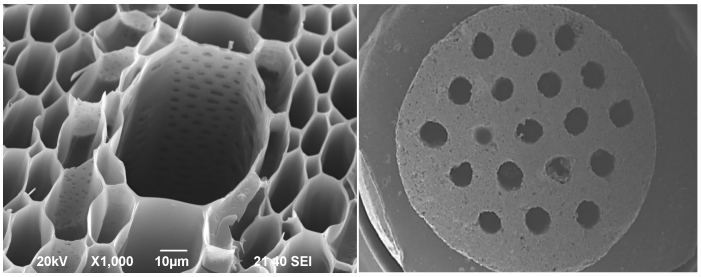


**Figure 1. SEM micrograph of Hemp and OS derived ACM**

| Table 1. Physico-chemical properties of the ACMs. | | | |
|---|---|---|---|
| ACM | $A_{BET}$ | At | $P_{(XPS)}$ |
| | $(m^2/g)s$ | $(m^2/g)$ | Atomic % |
| Hemp | 1486 | 555 | 1.94 |
| OS | 1250 | 318 | 0.8 |

Adsorption of CBZ and PA was evaluated over these ACMs. The best results were obtained for the natural ACM from hemp cane. Figure 2 shows the results of adsorption equilibrium and kinetics of CBZ and PA over this natural ACM at 25 ºC.

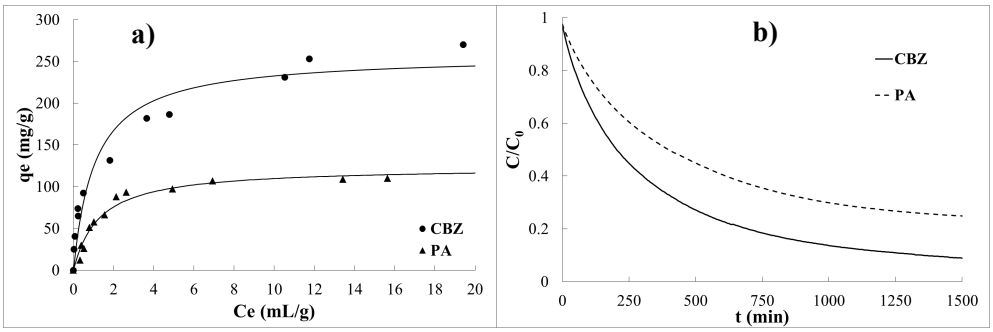


**Figure 2. Individual adsorption of CBZ and PA over the natural ACM at 25 ºC. A) Adsorption isotherm; b) Adsorption kinetics.**

Adsorption capacities of 200 and 120 mg/g were obtained for carbamazepine and paracetamol, respectively, at low equilibrium concentrations. Moreover, the simultaneous adsorption of carbamazepine and paracetamol was also evaluated, showing a competitive adsorption between both molecules.

## Conclusions

Natural ACM from hemp cane showed the best adsorption capacities and adsorption kinetics probably due to the higher apparent surface area and to the better molecules diffusion into the inner of the pores, as a consequence of the heterogeneity of their channels.

## Acknowledgment

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